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TRAINING MANUAL

PROPER HOLE PREPARATION IN AIRCRAFT MANUFACTURING

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Proper Hole Preparation in Aircraft Manufacturing

GENERAL DYNAMICS
Fort Worth Division

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LIST OF ILLUSTRATIONS

FOREWORD:

This manual contains general information about proper hole preparation in aircraft manufacturing at the Fort Worth Division of General Dynamics. It is to be used as a guide for the aircraft assembler in selecting the proper tools, in using these tools correctly and in drilling holes as prescribed by accepted practices. Detailed information on fastener holes and hole installation procedures may be found in Engineering Drawings, Process Standards, and "M" Standards.

Preparation of holes for the various fasteners seems to be a simple task. However, if done properly, the job requires considerable knowledge and skill. Hole drilling is an important step in making an airplane. A fastener hole meeting all of its specifications is one of the most important functions or responsibilities of an aircraft assembler. Proper hole installation is the key which helps to assure that a leak-proof fastener installation will be accomplished, that strength requirements will be met, and that a long flying life of our airplanes will be attained.

As new materials are developed for aircraft manufacture, new ideas in design and manufacture are also being developed. These new advances require that the aircraft assembler becomes familiar with the changes affecting his job. He should continue to develop his skills.

WE CANNOT AFFORD TO PURCHASE EXPENSIVE FASTENERS AND ALLOW PERSONNEL TO INSTALL THEM IN IMPROPERLY PREPARED HOLES IN EXTREMELY EXPENSIVE MATERIALS. WE MUST STRIVE TO ELIMINATE WASTE WHILE CONTINUING TO STRIVE FOR QUALITY.

INTRODUCTION:

The degree of structural soundness of our aircraft is related to how well you do your job. You are involved in building the world's best aircraft. It's performance depends upon your knowledge and skill. This fact is recognized by the customer when he describes the aircraft that we sell him as being a "QUALITY PRODUCT."

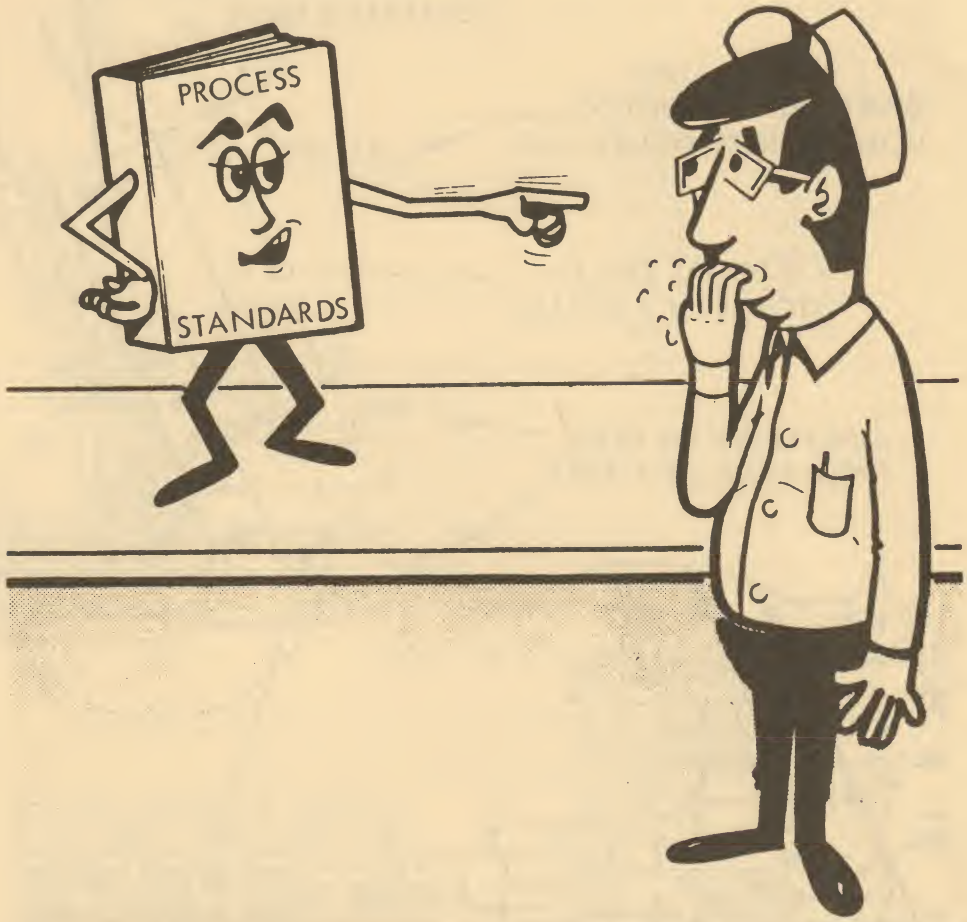
To achieve such a goal we must become adept and proficient in all phases of hole preparation.

This manual is intended as a supplement for training courses and as a reference guide for the general aircraft mechanic. No attempt has been made herein to include specific requirements for any particular size hole but rather to recognize the importance of hole preparation by the selection of proper equipment and cutting tools to perform the required operations.

The careful preparation of any fastener hole is just as important as careful attention is to fastener installation itself.

SHOP OPERATION PLANNING IS THE AUTHORIZED INSTRUCTION FOR PERFORMING YOUR JOB ASSIGNMENT.

Always Follow Process Standards (for info) - - - The high-heated materials, such as titanium, stainless steel, and D6AC steel, require special controls for drilling in order to prevent metallurgical damage to the material.



ALWAYS FOLLOW PROCESS STANDARDS!

FOLLOW APPLICABLE PROCESS STANDARDS CALLED OUT IN PLANNING OPERATION SHEET WHEN DRILLING HOLES IN THESE EXPENSIVE MATERIALS.

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Figure 1. Process Standards

ALWAYS CHECK ENGINEERING DRAWINGS

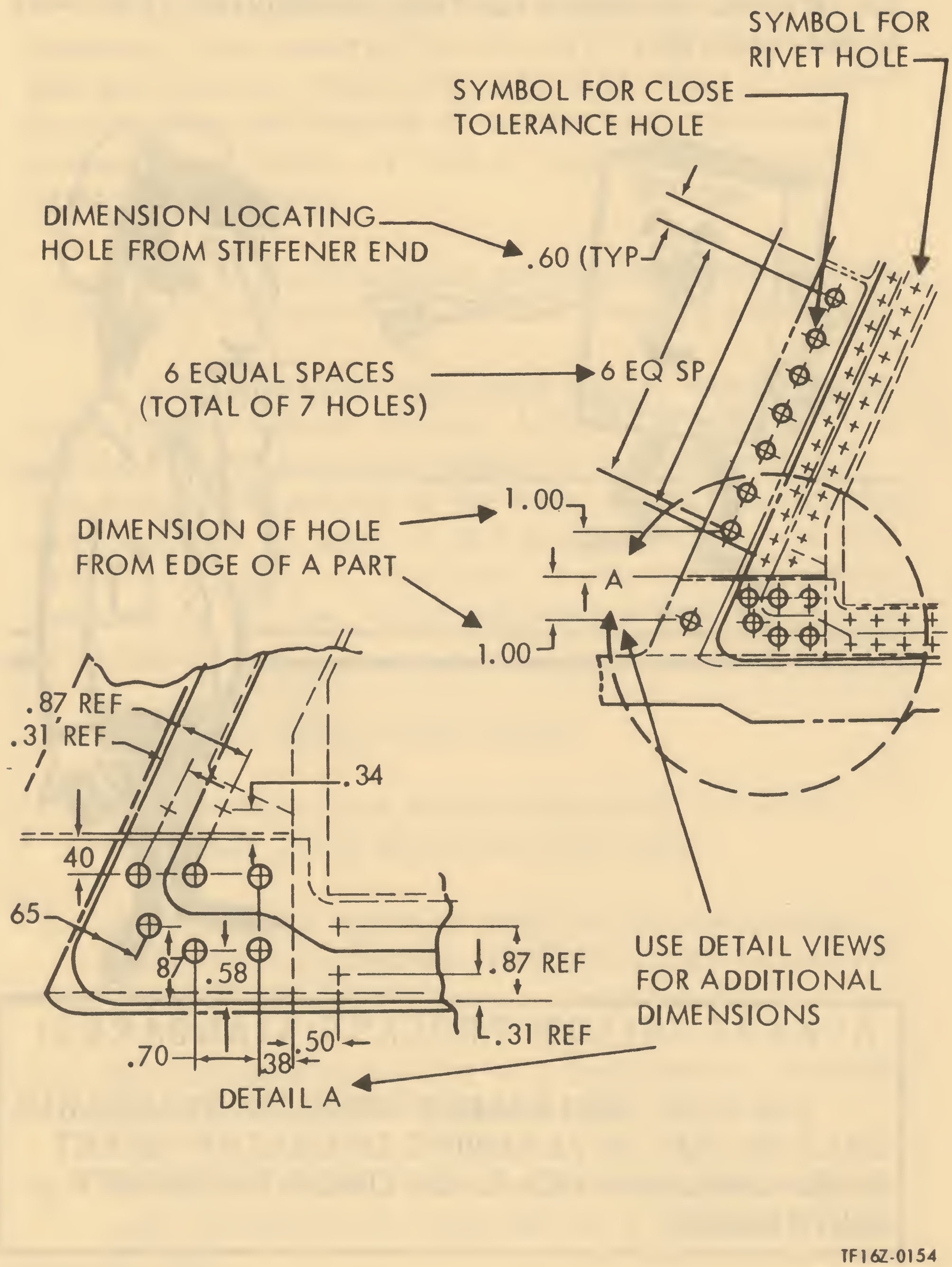


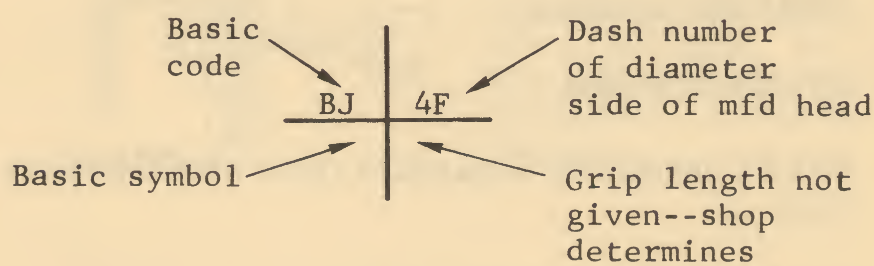
Figure 2. Engineering Drawings (Notes, Symbols and Dimensions (Sheet 1)

NAS523 CODE SYSTEM

The NAS 523 code system is used to identify fastener call-outs. The code is peculiar to the requirements of the drawing being studied and does not necessarily represent the same fastener requirement on any other drawing.

The code is always defined in the General Notes of the drawing where the hardware is listed by part number and code.

<u>Example</u>: Symbol Expansion (Rivet)



<u>Example</u>: ymbol Expansion (Bolt, screw)

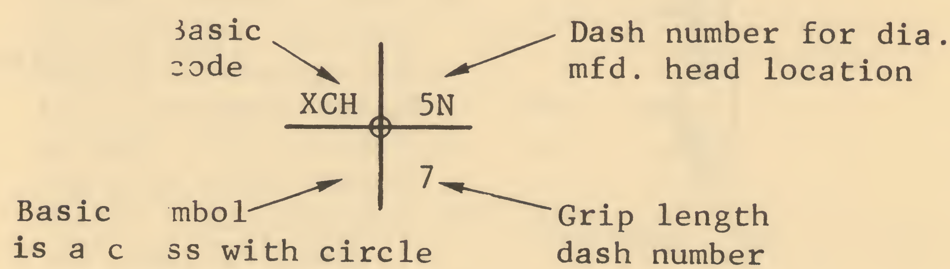


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Figure Engineering Drawings (Notes, Symbols and Dimensions (Sheet 2)

HOLE PREPARATION INFORMATION

Study the hole preparation information given on an Engineering Drawing.

1. ADDED NOTES - Always check for additional notes; they may be extremely important
2. DANGER - Observe instructions carefully
3. ADDITIONAL requirements (almost hidden in notes)
4. HOLE preparation standard (close tolerance)
5. SPECIAL symbols
6. SPOTFACE data
7. RIVET installation standard (hole size information)
8. SYMBOL interpretation.

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Figure 2. Engineering Drawings (Notes, Symbols and Dimensions (Sheet 3)

ENGINEERING DRAWING NOTES

(1) NOTES CONT'D SHEET 2.

5. INSTALL BOLTS AND NUTS WITH FMS 1044 INSTALL NUT WITH LOCKTITE AND UPSET THREADS ON BOLT COVER NUT AFTER INSTALLATION WITH FMS 1044 DRILL <u>BOLT HOLES PER M014-6 AND AT ROOT OF CSK ADD 270 DIA. X 60° CHAMFER</u>

(2)

(3)

4. ENGINEERING REF ONLY: CALC WT OF -1 IS 3.11
CALC WT OF -2 IS 4.36

3. 12B7301-1 SHOWN. 12B7301-2 OPP EXCEPT AS SHOWN. 12B7301-3 SHOWN. 12B7301-4 OPP.

(4)

2. HOLE PREPARATION DATA

FASTENER CODE	PIN DIA	HOLE PREPARATION
XCH XDA XCP XCV	-5	HOLE PER M014-4P
	-6	HOLE PER M014-5P
XBR	-6	1875/1890 CSK .382/100

(5)

1. SPOTFACE DIM

(6)

⊕ = SPOTFACE NEAR SIDE

⊞ = SPOTFACE FAR SIDE

(7)

◇C = SPOTFACE AND/OR C'BORE CLASSIFIED AS <u>CRITICAL</u> PER FZM-12-186 SHOT PEEN REQD.

(8)

FASTENER DIA DASH NO	SPOTFACE DIA AND RADIUS
-5	.43 DIA X .060 R
-6	.50 DIA X .060R

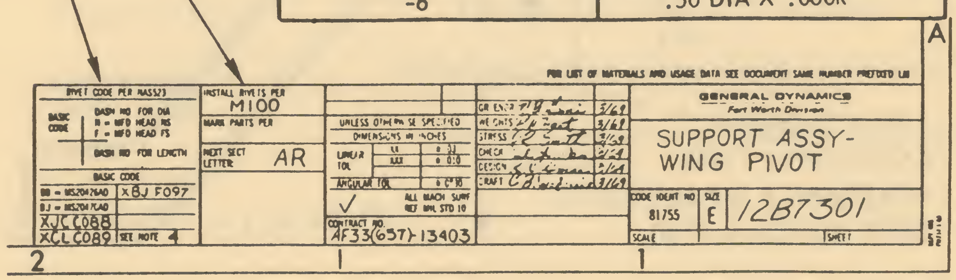

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Figure 2. Engineering Drawings (Notes, Symbols and Dimensions (Sheet 4)

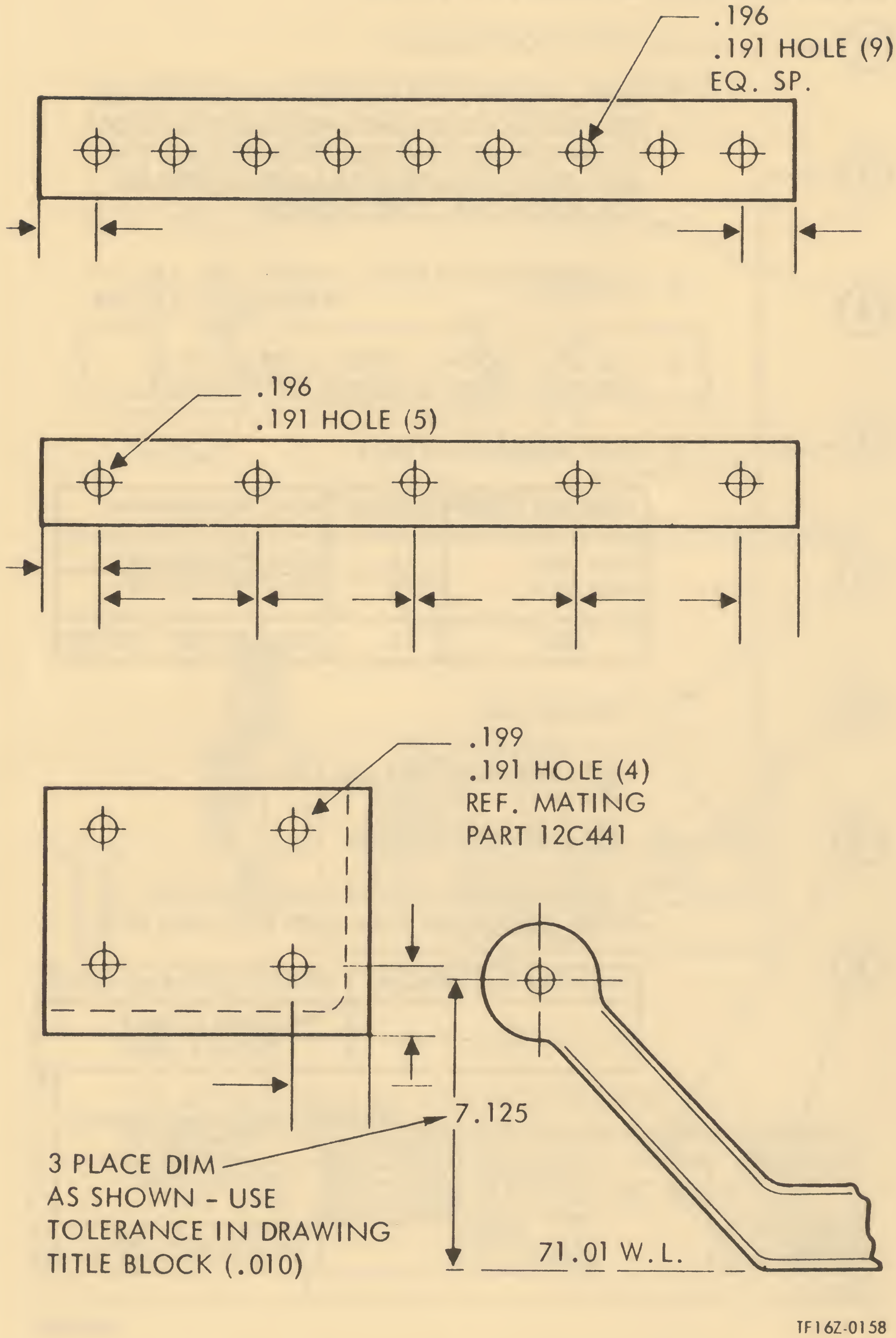

Figure 3. Hole Location Call-Outs

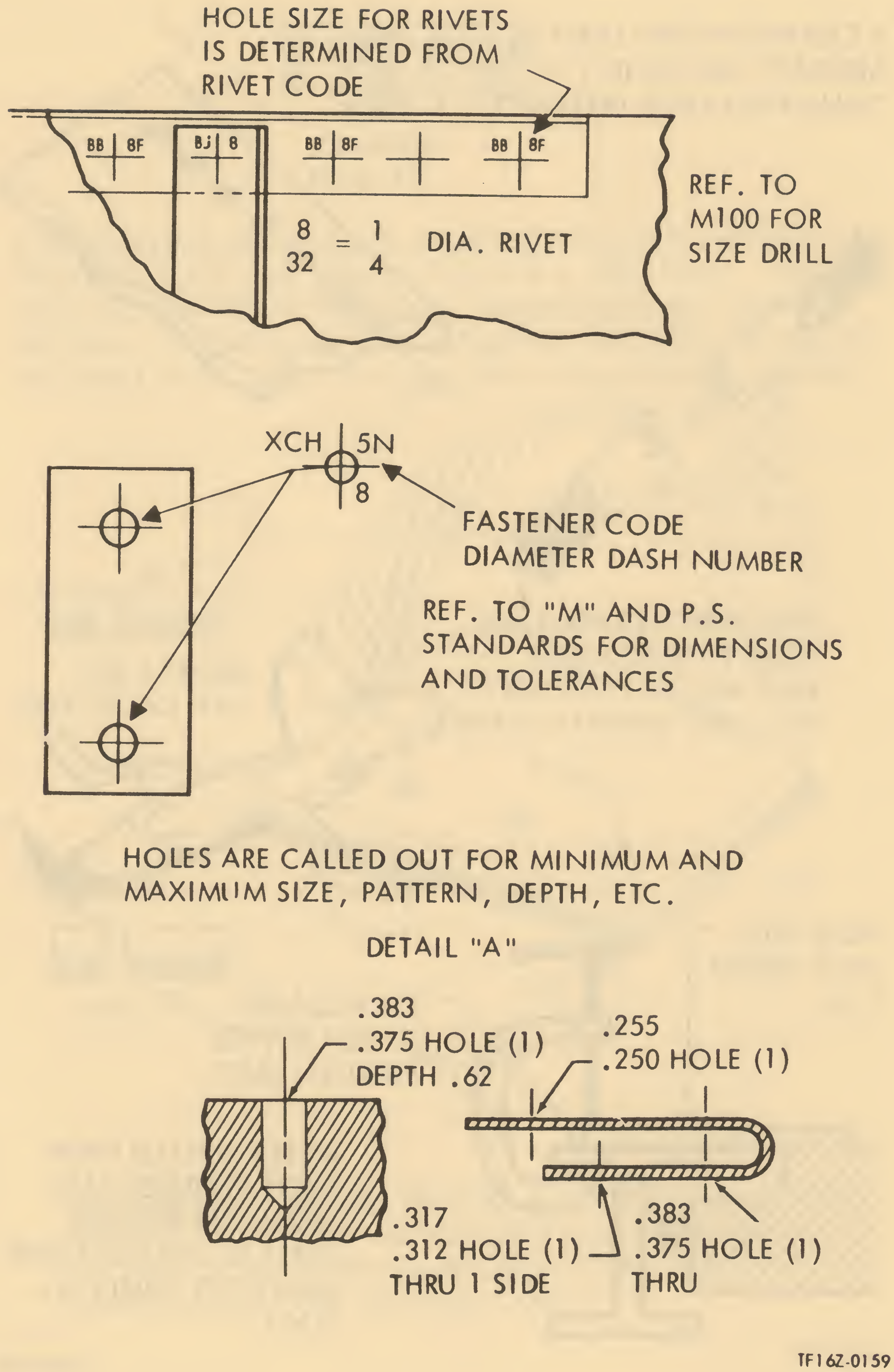

Figure 4. Rivet and Fastener Codes

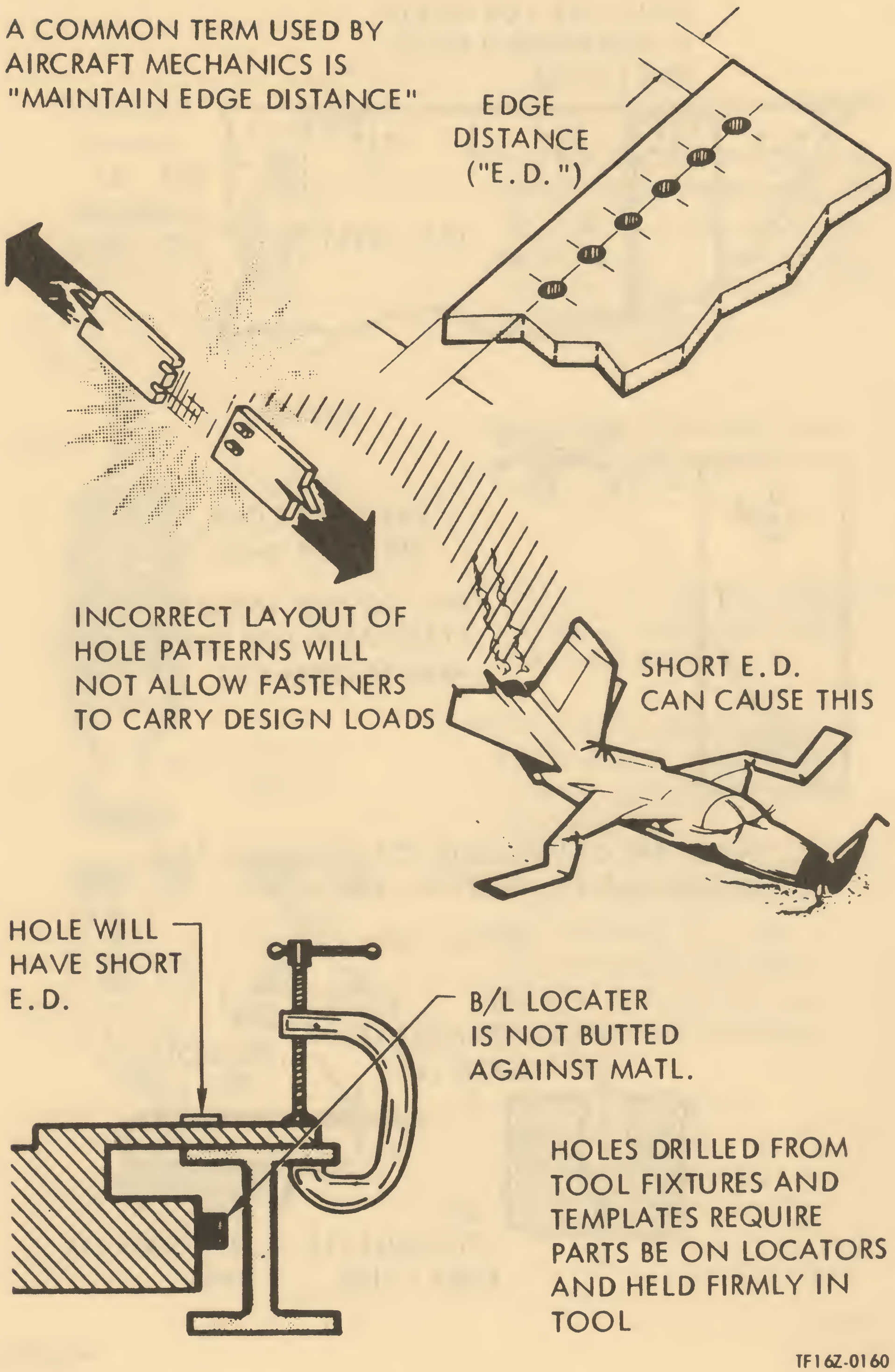

Figure 5. Edge Distance

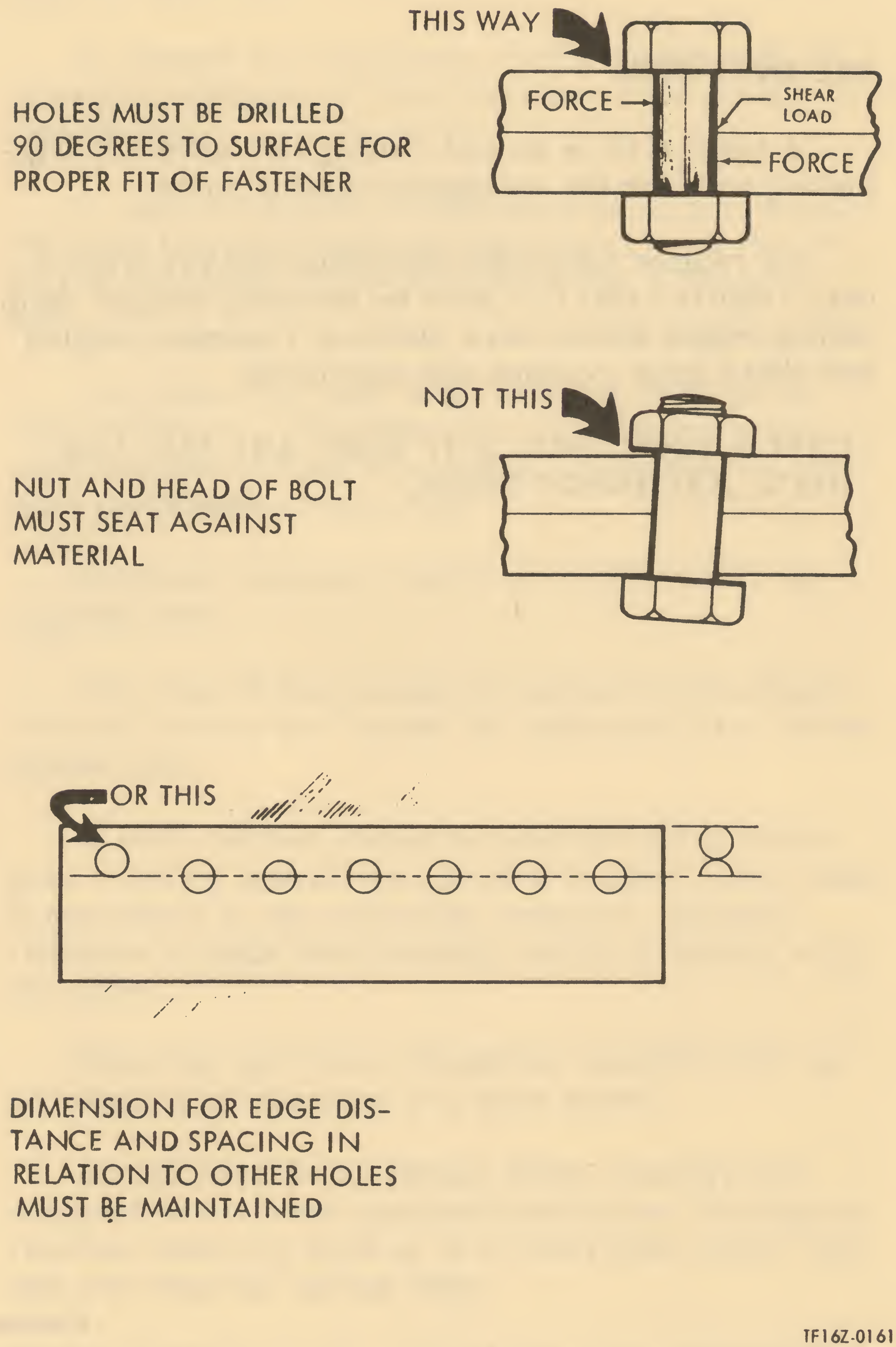

Figure 6. Proper Drilling Angle and Hole Spacing

THE TWIST DRILL

A twist drill is an end-cutting tool used for originating holes or for enlarging existing holes.

To realize maximum efficiency and life from a drill requires that it's point be properly shaped. Both cutting edges should have identical clearance angles and sharp point crushes and wearlands.

CHECK YOUR DRILLS, IF THEY ARE NOT CORRECT, EXCHANGE THEM.

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Figure 7. The Twist Drill (Sheet 1)

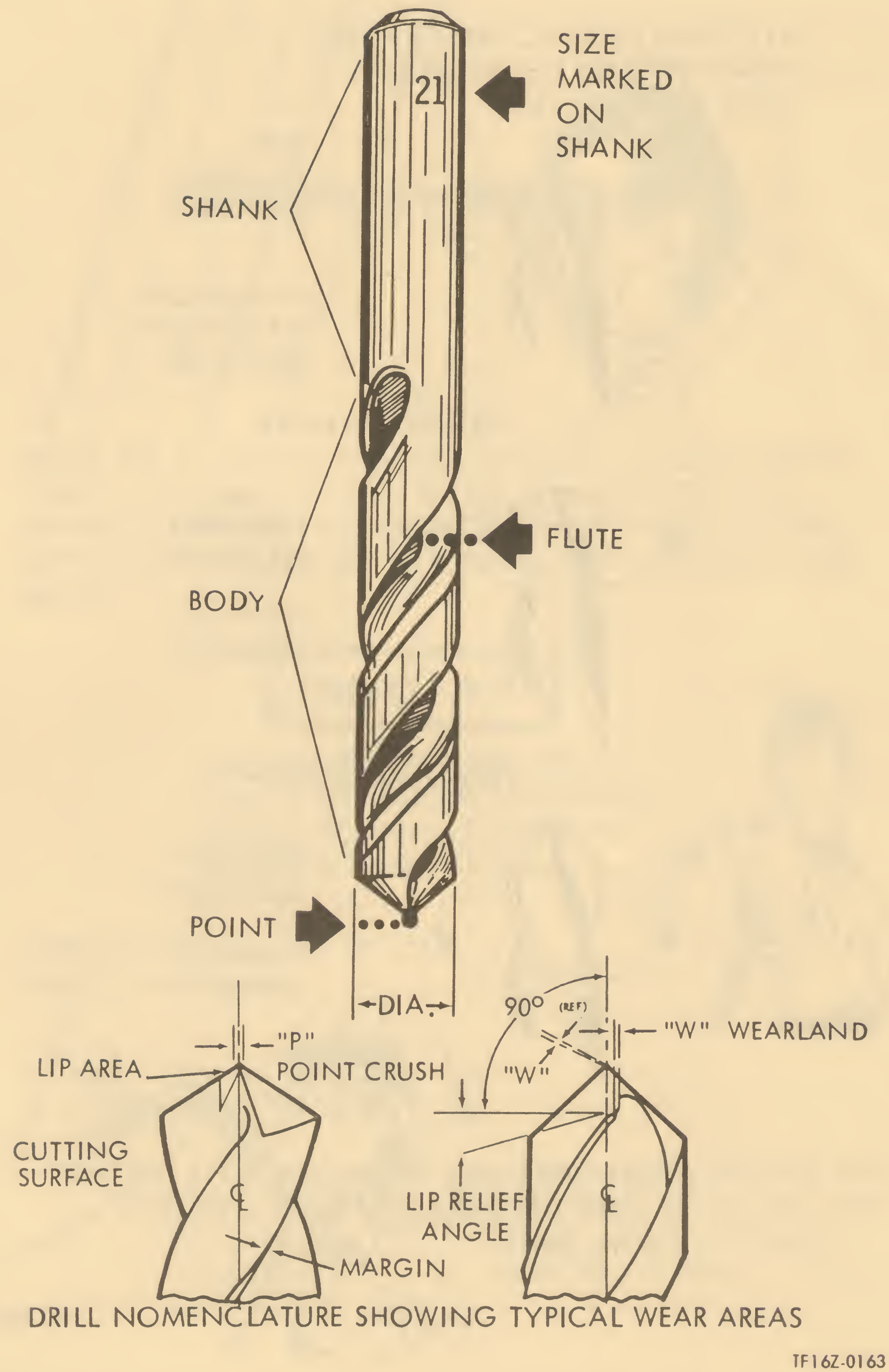


Figure 7. The Twist Drill (Sheet 2)

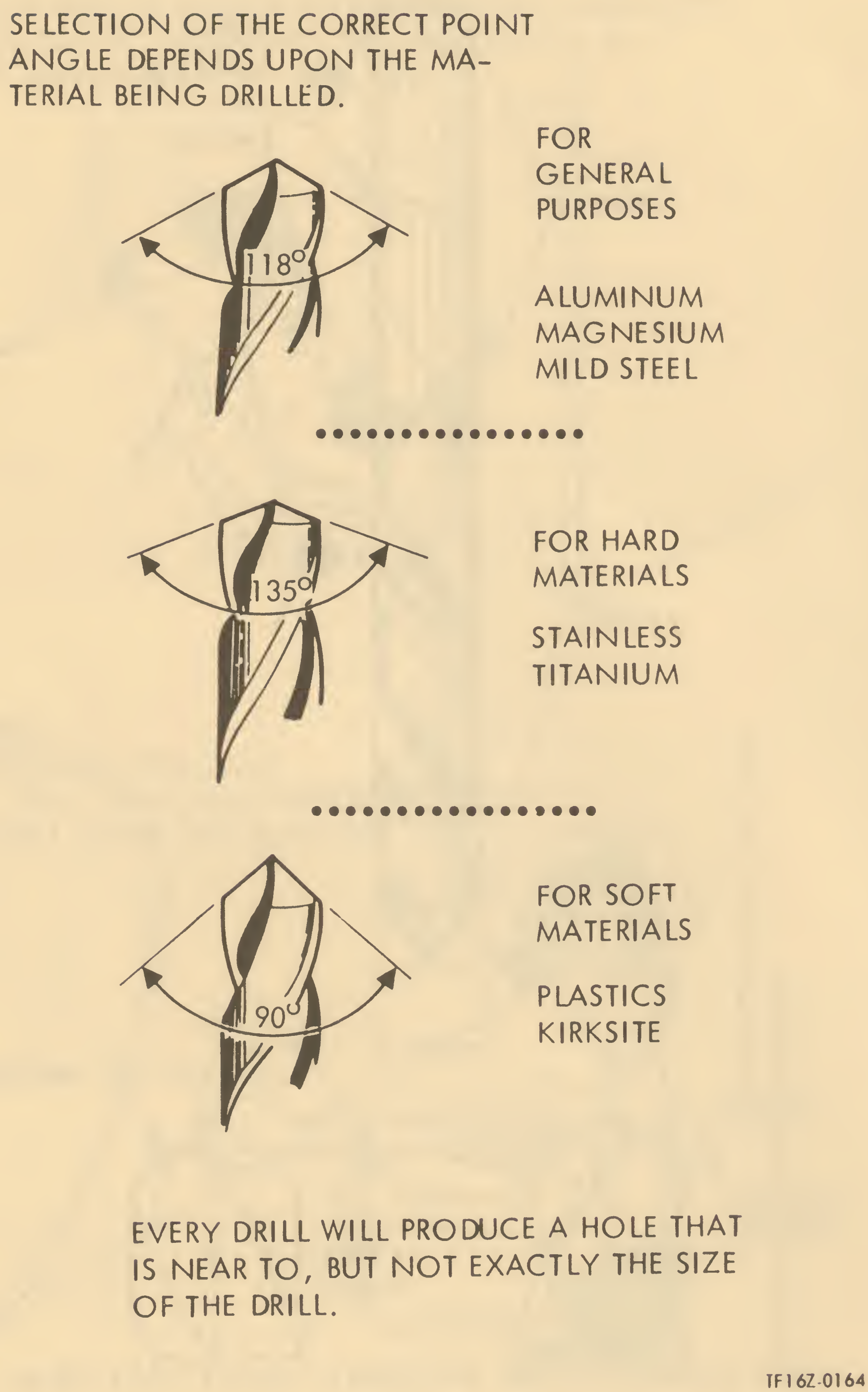


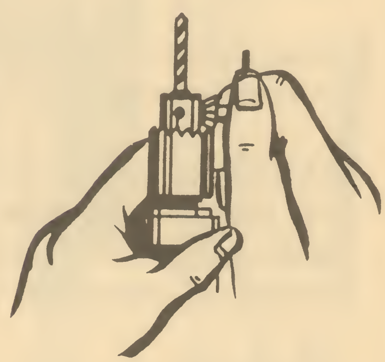
Figure 8. Selecting the Proper Drill

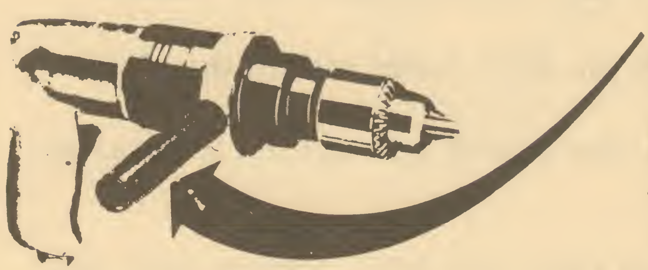
USE A CHUCK KEY TO OPEN THE JAWS ONLY FAR ENOUGH TO ADMIT THE SHANK OF THE DRILL. BE SURE DRILL SHANK AND CHUCK JAWS ARE CLEAN.

INSERT DRILL SHANK INTO CHUCK.

CAUTION: DO NOT ALLOW THE FLUTES TO ENTER CHUCK.

TIGHTEN THE CHUCK FIRMLY WITH THE CHUCK KEY, **INSERTING THE KEY IN ALL THREE HOLES.** THIS PREVENTS UNEQUAL CLAMPING ON THE DRILL.





OFFSET HANDLES ON HARD MOTORS HELP TO MAINTAIN RIGIDITY AND TO CONTROL TORQUE WHEN DRILLING THICK MATERIAL

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Figure 10. Chucking the Drill

TIPS ON DRILLING

1. Always make certain you get the size drill you ask for.
2. Size of drill is stamped on shank. Drill gauges are available at the tool crib for verification.
3. Sharp, straight drills produce uniform size chips and small burrs on far side of material being drilled.
4. Dull drills produce powdery chips and large burrs.
5. Crooked drills tend to creep on the material surfaces, causing scratches and short edge distances.
6. Bent drills induce motor vibration and result in oversize holes.
7. Aluminum alloys are easily heated when drilling and tend to coat the drill with clad (pure aluminum) material. This "clad-buildup" can cause oversize holes and scoring of the hole wall.
8. Never force a drill into an undersize chuck.
9. Do not tighten the drill flutes within the chuck.
10. Always use a sharp drill and tighten it securely in the chuck.
11. Never sharpen your own drill. Return dull, bent or defective drills to the tool crib.

12. Over-heating, dulling, or chipping of the outer lip area of a drill usually occurs during final breakthrough of the drill point as the hole is completed. Use of back-up plates (placed on the back side) is recommended.

13. Drills are made of hard, brittle materials and break easily. HANDLE WITH CARE; DRILLS COST MONEY!

14. Holes must be drilled "normal" to the surface that the fastener will seat against, unless otherwise specified. "Normal" means 90 degrees to the surface; for contoured surfaces this means 90 degrees to point of tangency.

15. It is impossible to drill a perfectly round hole at any angle other than 90 degrees to the surface of the material being drilled.

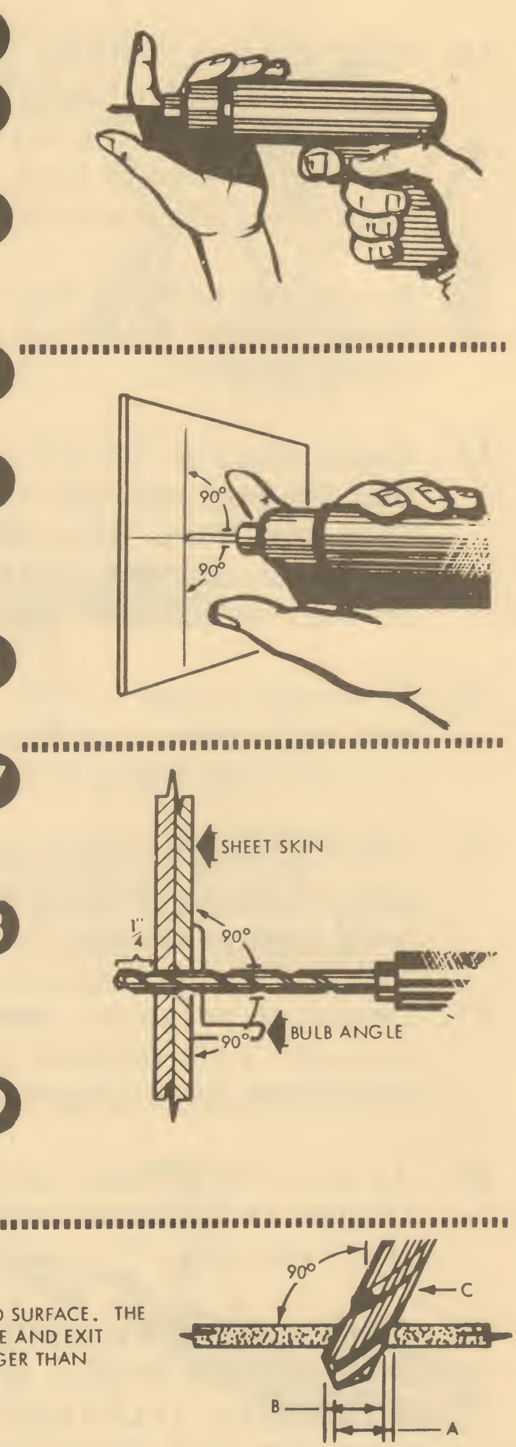
16. The thickness of the material determines the amount of pressure to be applied. Thin materials need less pressure.

17. Decrease pressure when drill is ready to break through. This lessens chance of heavy burrs and elongated holes occurring.

18. As the drill breaks through the material the trigger is released and the drill pulled straight from the hole.

19. APPLY MAIN PRESSURE ON THAT PART OF THE MOTOR WHICH IS DIRECTLY BEHIND THE DRILL TO AVOID POSSIBLE ELONGATION OF THE HOLE BEING DRILLED.

1. HOLD MOTOR FIRMLY.
2. PUT DRILL POINT ON SPOT TO BE DRILLED.
3. HOLD DRILL AT A 90 DEGREE ANGLE TO THE MATERIAL'S SURFACE.
4. START MOTOR BY SQUEEZING TRIGGER.
5. SUPPORT DRILL MOTOR TO PREVENT CHUCK FROM TOUCHING AIRCRAFT PART.
6. PUSH DRILL WITH SUFFICIENT PRESSURE TO DRILL HOLE.
7. DRILL THROUGH MATERIAL NO MORE THAN $\frac{1}{4}$ INCH.
8. KEEP MOTOR RUNNING WHILE WITHDRAWING DRILL FROM HOLE.
9. BE SURE DRILL IS HELD AT AN ANGLE 90 DEGREES TO THE DRILLED SURFACE.



A DRILL NOT HELD 90 DEGREES TO SURFACE. THE HOLE DIAMETER AT THE ENTRANCE AND EXIT SURFACES (A AND B) WILL BE LARGER THAN DIAMETER OF DRILL (C).

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Figure 11. Drilling A Hole (Sheet 1)

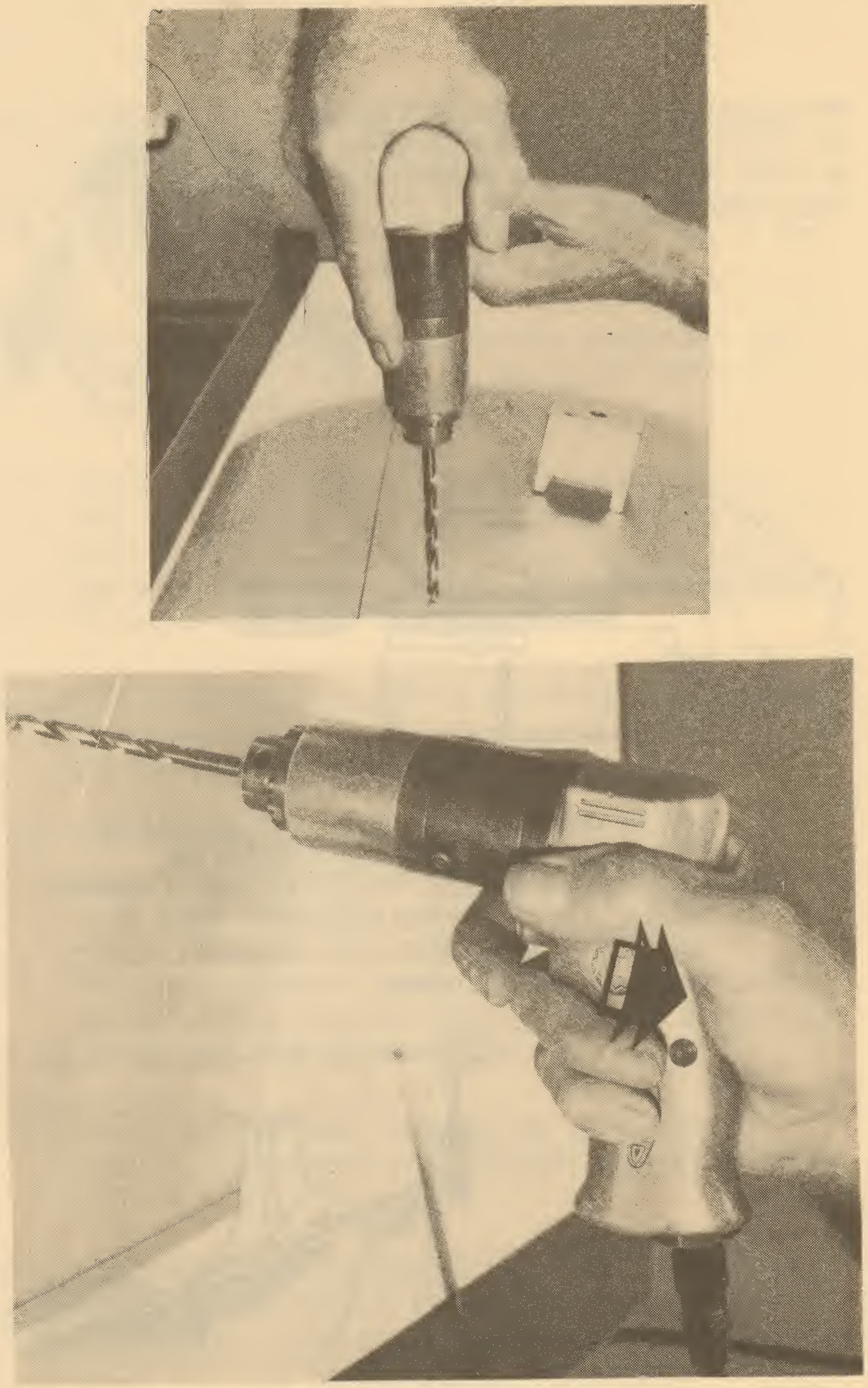

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Figure 11. Drilling A Hole (Sheet 2)

THE LOCATION OF THE HOLE DETERMINES THE TYPE OF DRILLING EQUIPMENT TO BE USED. BE SURE THE EQUIPMENT YOU SELECT WILL DO THE JOB.

BEFORE DRILLING ANY HOLE, THE OTHER SIDE OF THE MATERIAL TO BE DRILLED MUST BE CLEAR OF HYDRAULIC LINES, ELECTRICAL WIRING, PEOPLE, OR ANYTHING ELSE THAT MIGHT BE DAMAGED OR INJURED WHEN THE DRILL COMES THROUGH THE MATERIAL

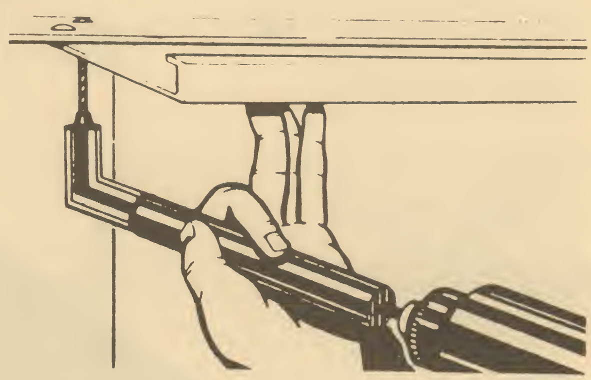

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Figure 12. Special Tools (Sheet 1)

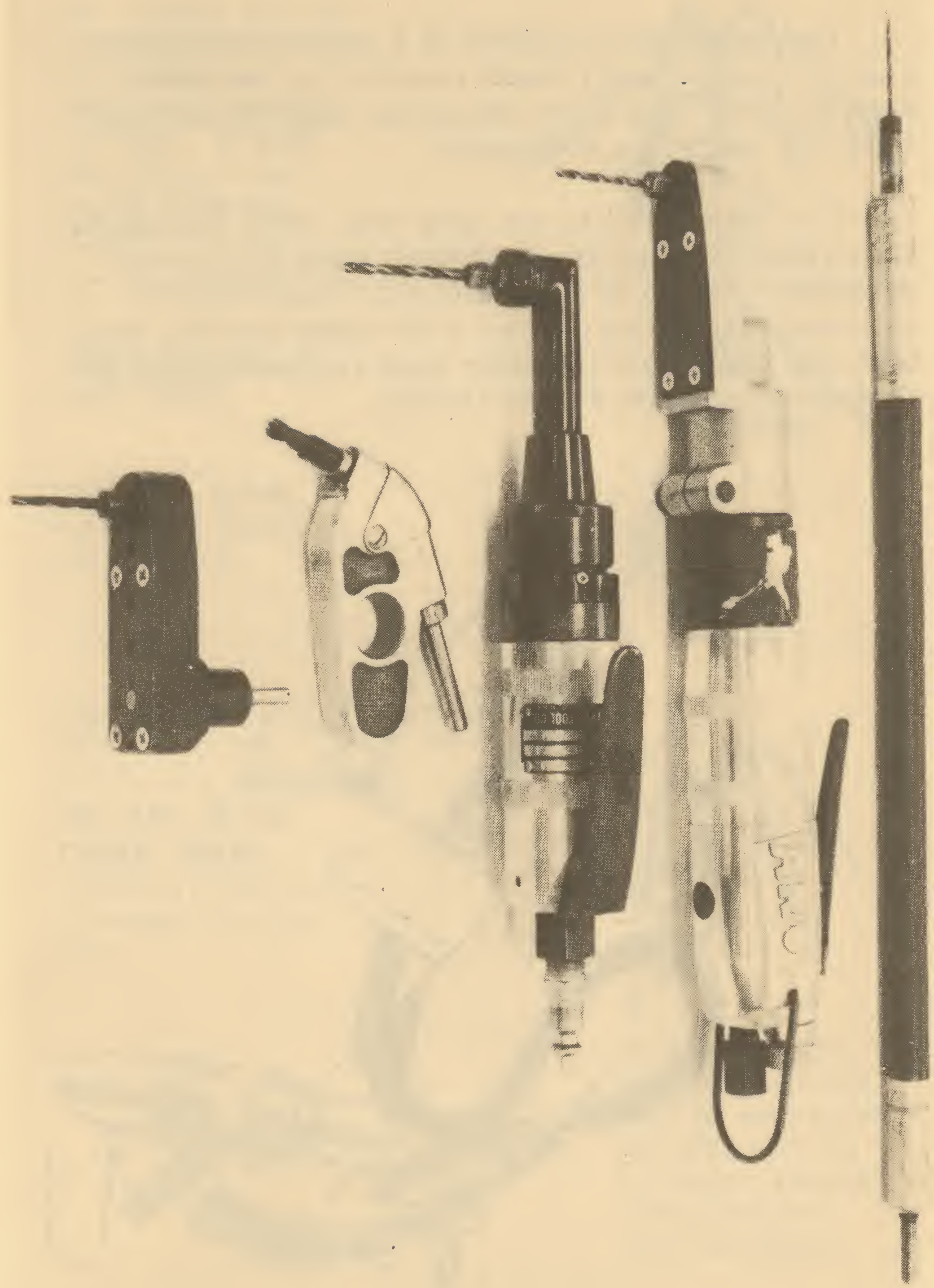

Figure 12. Special Tools (Sheet 2)

The snake drill consists of a cable in a flexible housing, with a small chuck mounted on one end to hold the drill. The other end of the cable is designed to fit the chuck of a drillmotor.

The snake drill is not used very often, but due to its flexibility there are occasions when it is a very necessary tool. It is more difficult to use than the extension drill. The guiding of the drill must be done with one hand while the other hand is used to hold the drillmotor and operate the trigger.

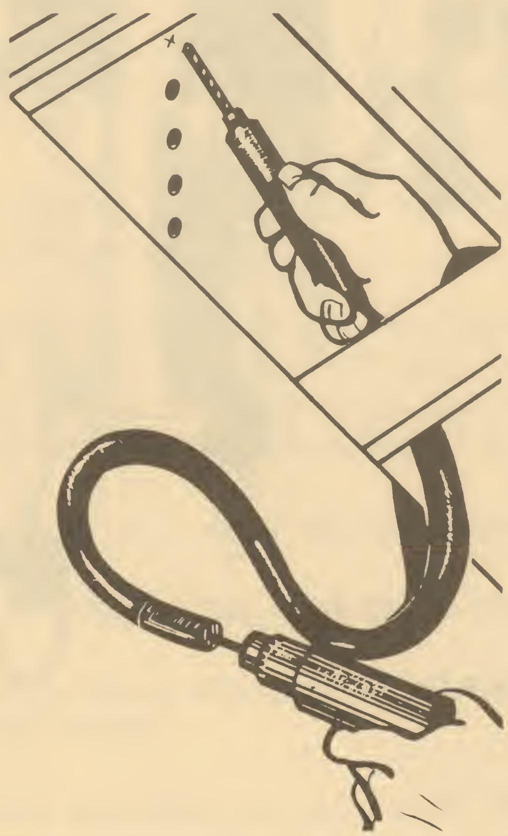

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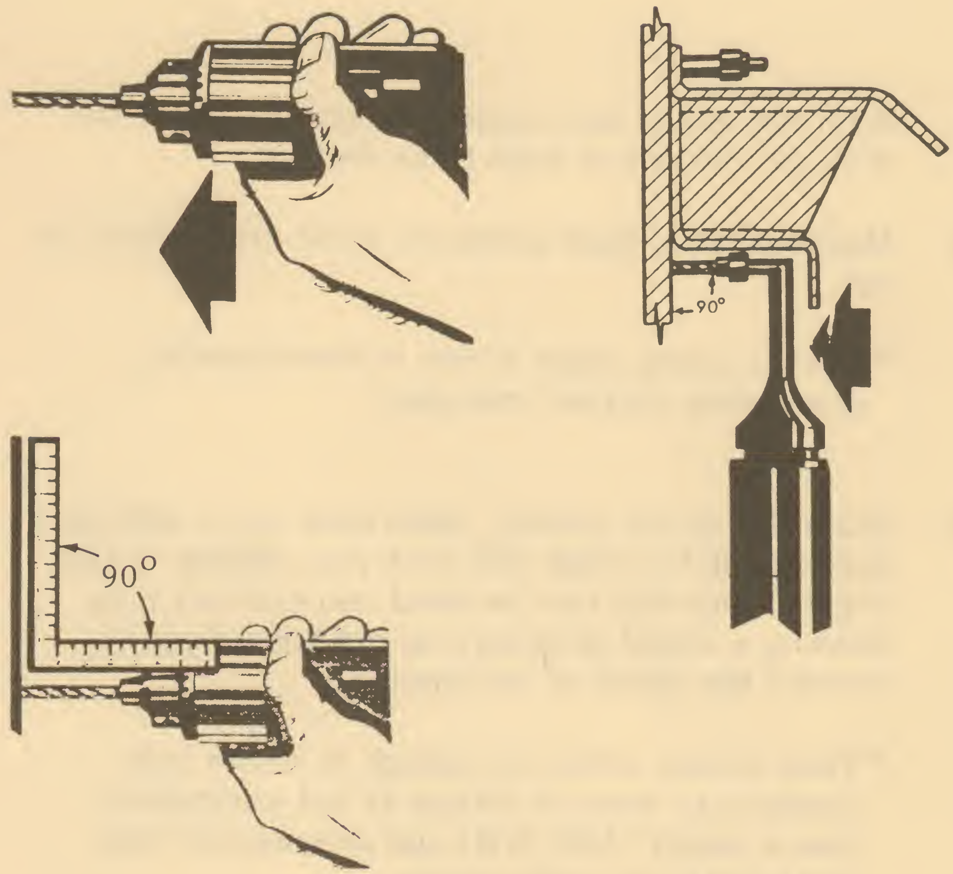
Figure 13. Use of Angle Motors and Drill Motor Attachments (Sheet 1)



• Many holes are located in places that will not permit the use of straight drills. Special angle motors and drilling motor attachments may be used in these inaccessible places.

• Using this equipment differs from use of straight drills only in the pressure that is applied to the drill.

• For straight drilling, the pressure is applied in line with the motor and drill; for angle drilling, the pressure is applied in line with the drill only.

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Figure 13. Use of Angle Motors and Drill Motor Attachments (Sheet 2)

1. With the motor not running, place the tip of the drill at location of hole to be drilled.

2. Maintain very light pressure until drill starts to cut.

   - Skill in using angle drills is developed by practicing correct methods.

3. Start the motor slowly, otherwise there will be a torquing action that will jerk your motor to the right. Keep this fact in mind and correct it by holding a slight pressure to the left as you increase the speed of drillmotor.

   - This torque action is enough to cause hole location to move if torque is not controlled. Use a small (#40) drill and subsequent hole sizing will be made easier.

4. Just before the drill breaks through the material, release the pressure on the drill gradually to prevent the chuck from making contact with the material, it could damage the part.

5. With the motor still running, remove the drill from the hole with a steady, straight pull. Keep the drill at a right angle to the surface.

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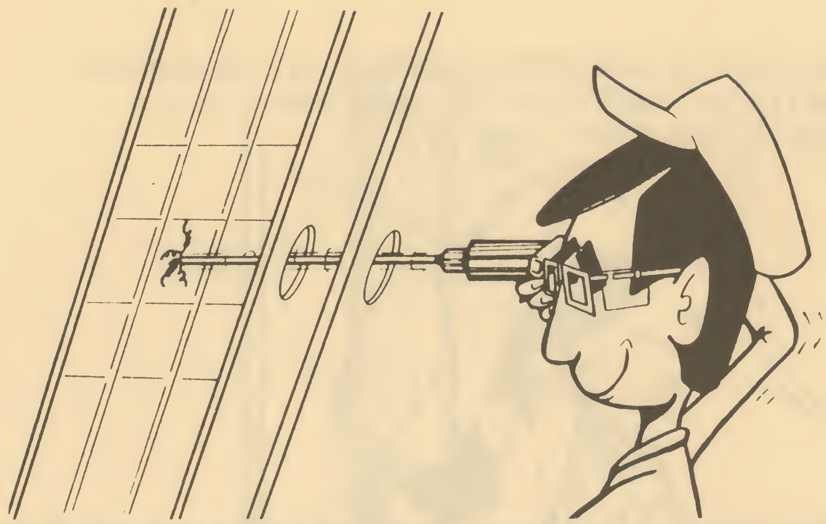
Figure 13. Use of Angle Motors and Drill Motor Attachments (Sheet 3)

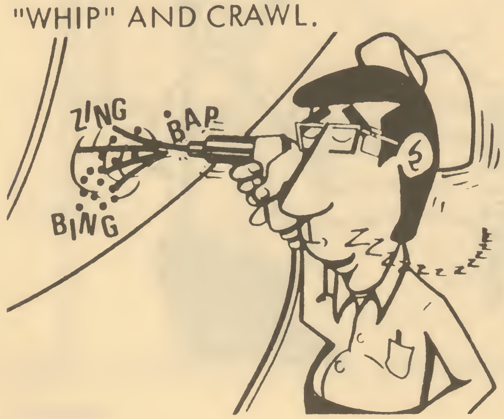


DRILLS ARE AVAILABLE IN MANY LENGTHS. A DRILL WITH A SHANK LONGER THAN THAT FOR A STANDARD DRILL IS REFERRED TO AS AN EXTENSION DRILL. IT IS USED TO DRILL IN PLACES THAT CANNOT BE REACHED WITH STANDARD SIZE DRILLS.

SAFETY FIRST

CARELESS USE OF THESE DRILLS CAN CAUSE SERIOUS ACCIDENTS. IF USED PROPERLY, EXTENSION DRILLS ARE SAFE TOOLS.

SUPPORT THE DRILL TO PREVENT "WHIP" AND CRAWL.



MANY SKIN SCRATCHES AND EGG SHAPE HOLES ARE CAUSED BY UNCONTROLLED SUPPORT OF DRILL.

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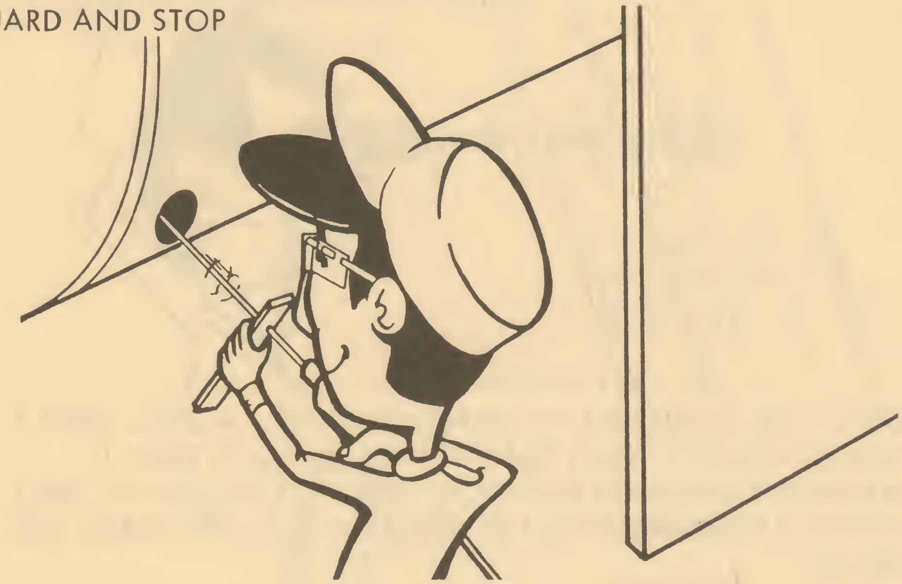
Figure 14. Extension Drills (Sheet 1)

THE DRILL MAY BE SUPPORTED BY USING AN ALUMINUM TUBE OR PLASTIC FIBER OVER THE DRILL SHANK AS A GUARD AND STOP



REMEMBER!!!
HOLD THE DRILL STRAIGHT
DON'T APPLY TOO MUCH PRESSURE
USE A DRILL GUIDE FOR SUPPORT.

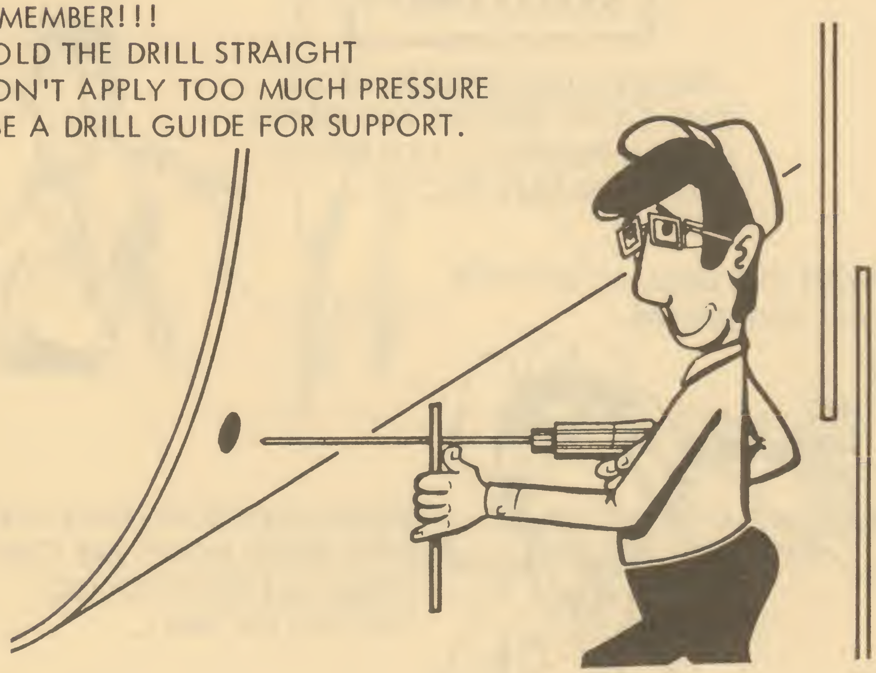


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Figure 14. Extension Drills (Sheet 2)

USE OF REAMERS

A reamer is a precision rotary cutting tool. It is used to enlarge, or finish to size, a previously drilled hole.

A reamer is used to remove a small amount of material from the walls of a hole to achieve the required dimension (close tolerance) for a fastener hole.

The pilot-size hole (#40) used for location is step-drilled to 1/64 undersize of completed hole; then, reamed to final size, using a pilot reamer with pilot correlated to hole size.

Oversize reamers must have a pilot to fit the original hole.

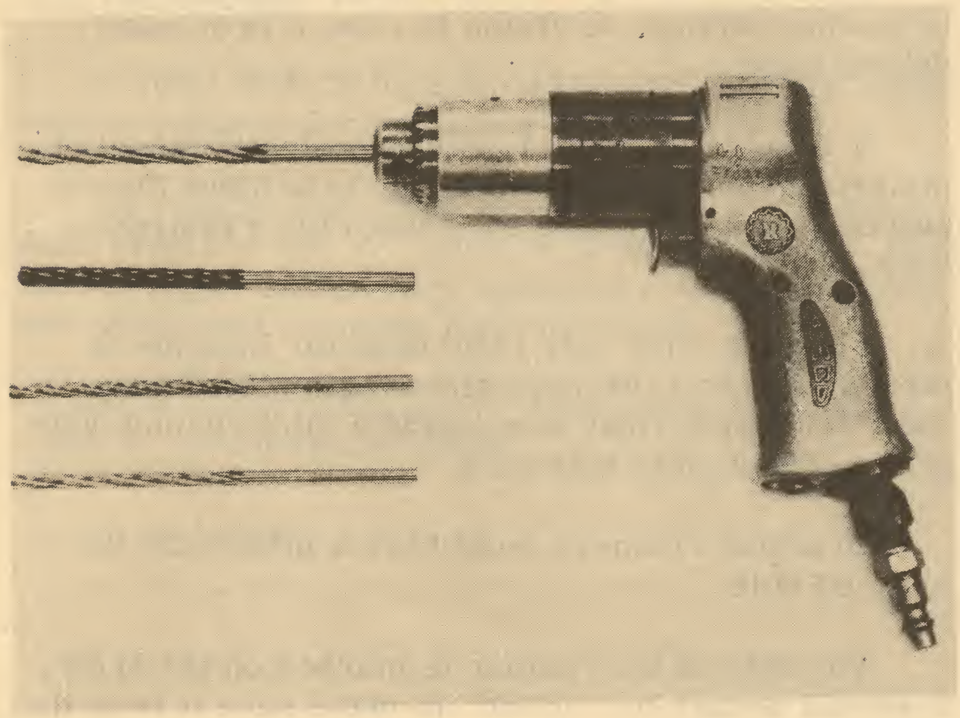
The size of the reamer is marked on the shank. It should always be "miked" to make sure it is of the proper size.

A pilot reamer should be used for all portable hand reaming operations. Access to some holes make it necessary to use extension reamers, threaded reamers in angle attachments, and/or reamers without pilots.

Reaming operations should be carefully set-up and equipment operated at a slow speed.

Do not reverse a reamer. Most reamers are designed to cut when operated clockwise. Turning in reverse either by hand or in a reversible motor will dull and chip the cutting edge.

HANDLE WITH CARE - REAMERS ARE EXPENSIVE.



A reamer must be fed into a hole on a straight line and extracted on the same straight line. Any movement from side to side or up and down from this straight line will produce an egg shaped hole.

A hole should be reamed only once. Do not run the reamer back in the hole after it has been reamed.

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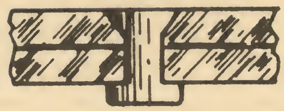
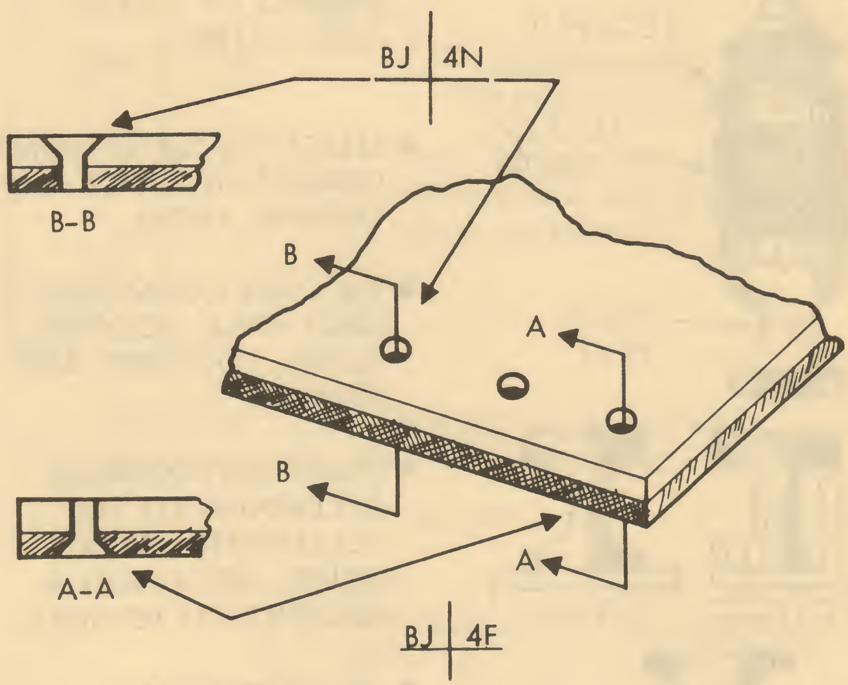
Figure 15. Reamers



COUNTERSINKING IS ACCOMPLISHED BY USING A SPECIAL CUTTING TOOL IN A DRILLMOTOR OR A DRILLPRESS. THE HOLE IS PREPARED TO NOMINAL DIMENSIONS BUT WHEN PROPERLY PREPARED, BE OF SUCH DEPTH THAT THE INSTALLED FASTENER HEAD WILL FIT FLUSH WITH THE MATERIAL SURFACE.



FLUSH-HEAD FASTENERS REQUIRE A COUNTERSUNK HOLE PREPARED FOR THE MANUFACTURED HEAD TO NEST IN. THE SIDE OF THE WORK TO BE COUNTERSUNK IS DESIGNATED BY THE FASTENER CODE.

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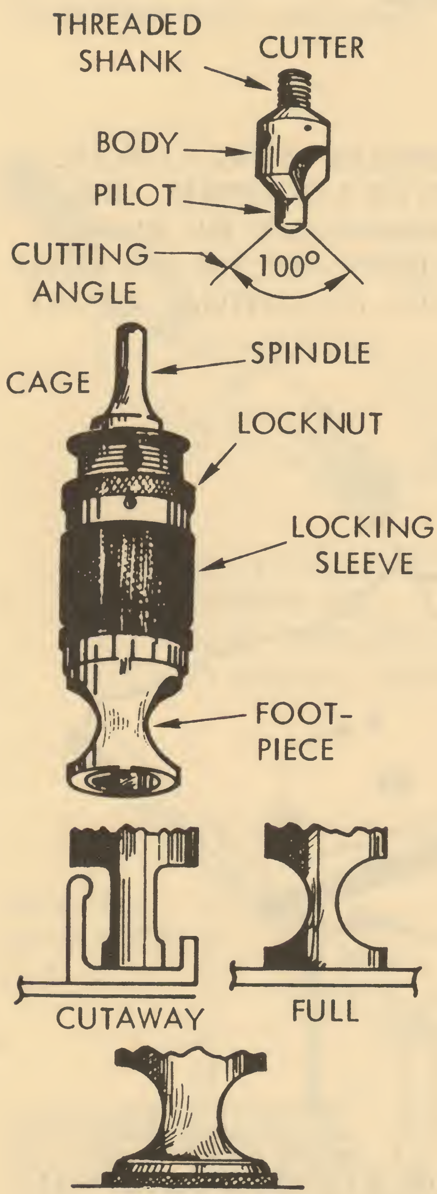
Figure 16. Countersinking (Sheet 1)



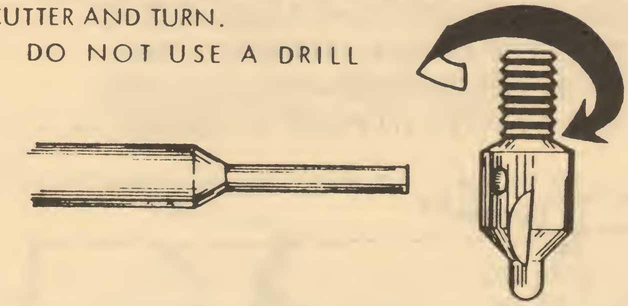
- THE STOP COUNTERSINK IS FASTER AND PRODUCES MORE ACCURATE AND UNIFORM RESULTS. IT IS ADJUSTABLE TO .001" FOR DIFFERENT CUTTING DEPTHS.
- THE STOP COUNTERSINK CONSIST OF A CAGE AND CUTTER.
- SELECT THE CUTTER WITH THE CORRECT PILOT SIZE AND CUTTING ANGLE.
- THE CAGE CONSISTS OF A FOOT-PIECE, LOCKING SLEEVE, LOCKNUT, AND SPINDLE.
- SELECT THE FOOTPIECE ACCORDING TO THE ACCESSIBILITY OF THE HOLES. USE AS FULL A FOOTPIECE AS POSSIBLE.
- USE SPECIAL FOOT PIECE FOR SKIN COUNTERSINKING.

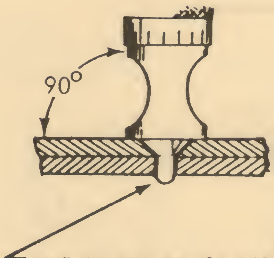
TF16Z-0179

Figure 16. Countersinking (Sheet 2)

THE CUTTER SCREWS INTO THE SHAFT AND CAN BE REPLACED WHEN DULL. TO TIGHTEN OR LOOSEN THE CUTTER, INSERT A PUNCH OF THE CORRECT SIZE INTO HOLES IN SIDE OF CUTTER AND TURN.

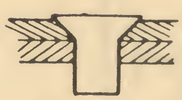
DO NOT USE A DRILL





THE PILOT MUST FIT THE HOLE.

- THE COUNTERSINK MUST BE ADJUSTED BY TRIAL AND ERROR.
- ALWAYS ADJUST THE COUNTERSINK ON SCRAP MATERIAL -- NEVER ON THE AIRPLANE OR PART.
- HOLD THE COUNTERSINK 90 DEGREES TO THE MATERIAL.
- HOLD THE FOOTPIECE FIRMLY; DO NOT ALLOW THE FOOTPIECE TO SPIN AGAINST THE METAL.
- START WITH THE COUNTERSINK CUTTING SHALLOW.
- TEST DEPTH OF CUT WITH RIVETS.
- CONTINUE ADJUSTING AND TESTING UNTIL THE PROPER DEPTH IS REACHED.
- BE SURE LOCKNUT IS TIGHTENED.
- COUNTERSINK ALL HOLES AS REQUIRED.
- CHECK DEPTH OF COUNTERSUNK HOLES FREQUENTLY.



TOO SHALLOW (INCORRECT)

FLUSH (CORRECT)

TOO DEEP (INCORRECT)

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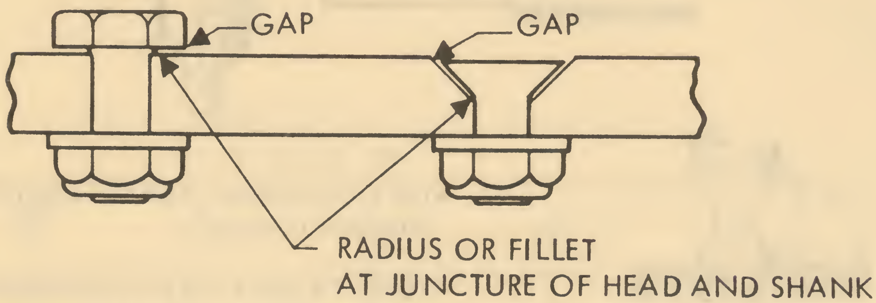
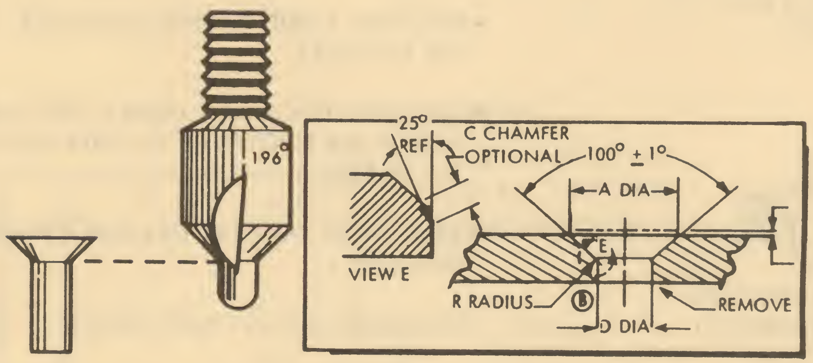
Figure 16. Countersinking (Sheet 3)

THE BOTTOM OF THE COUNTERSINK MUST BE RADIUSED TO PERMIT SOME FASTENERS TO NEST INTO THE RADIUS. PRIMARLY THIS CHAMFER IS NEEDED WHEN THE FASTENER IS TO BE INSTALLED IN HARD MATERIALS.





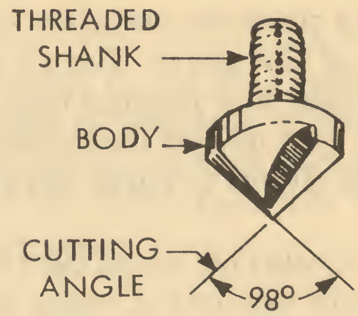
THE APPLICATION OF THIS REQUIREMENT WILL BE SPECIFICALLY CALLED OUT ON ENGINEERING DRAWINGS.

TF16Z-0181

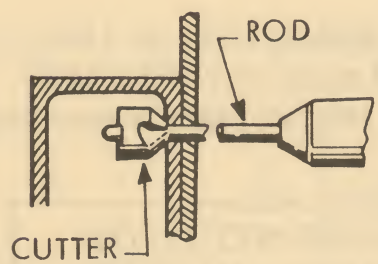
Figure 16. Countersinking (Sheet 4)

COUNTERSINK CUTTER FOR ANGLE DRILLS

THIS CUTTER IS USED WITH ANGLE DRILLS. USE ONLY IF NO OTHER COUNTERSINK WILL DO THE JOB



THE BACK COUNTERSINK



USE TO COUNTERSINK INACCESSIBLE HOLES. THE ROD MUST BE THE SAME SIZE AS THE HOLE. PUT ROD THROUGH THE HOLE, THEN ATTACH CUTTER TO THE ROD.

STRAIGHT SHANK

USE IN HAND DRILL. THE CUTTING ANGLE IS MARKED ON THE BODY. CUTTING ANGLES COMMONLY USED ARE 100 DEGREES AND 110 DEGREES. THE DIAMETER OF THE BODY VARIES FROM $\frac{1}{4}$" TO $1\frac{1}{2}$". A COUNTERSINK OF 3/8" DIAMETER IS MOST COMMONLY USED.

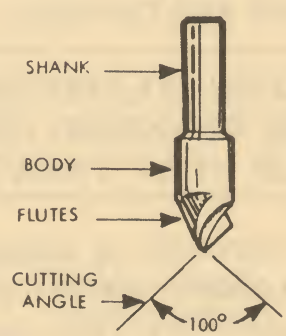


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Figure 16. Countersinking (Sheet 5)

DEBURRING

Burrs prevent metal-to-metal contact at faying surfaces of the parts. Burrs are small portions of material that are pushed (not cut) out by the force of the drill. The use of dull cutting tools and excessive pressures (feed) creates larger burrs.

This material must be removed to prevent fasteners from becoming loose under loads and vibration. The wearing action of a loose joint will induce fretting corrosion into the material.

Proper deburr of holes is essential for structural soundness of the aircraft.

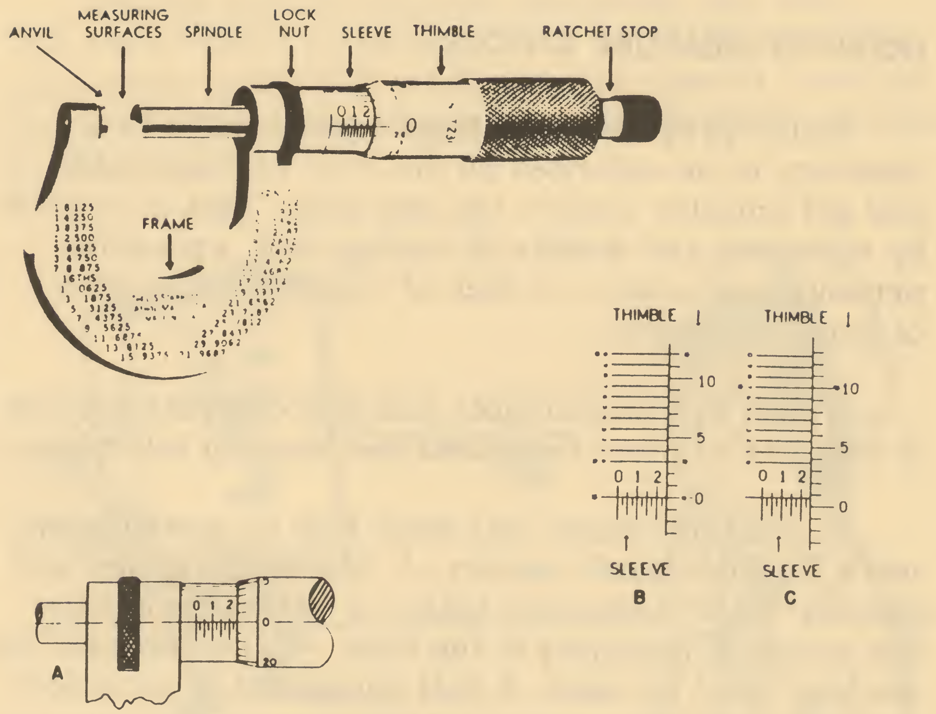
Holes may be deburred with a 100- or 120-degree cutter in a low-speed airmotor. The tool should cut clean with one or two strokes, removing ONLY the sharp edge.

> BALANCE THE FEED AND SPEED OF THE MOTOR TO PREVENT CHATTER MARKS.

Refer to Tool Drawing C-15341 for approved deburr tool and cutters.

> REFER TO PROCESS STANDARD 22.02-6 AND PLANNING CARD FOR DEBURR OF HIGH HEAT TREATED MATERIALS.

The surfaces of aluminum alloys are soft and tend to produce heavier burrs than non-clad aluminum. These materials should be clamped firmly together to minimize the accumulation of burrs.



The Vernier consists of ten divisions on the sleeve, shown in figure B, which occupy the same space as nine divisions on the thimble. Therefore, the difference between the width of one of the ten spaces on the Vernier and one of the nine spaces on the thimble is one-tenth of a division on the thimble, or one-tenth of one-thousandth, which is one ten-thousandth. To read a ten-thousandths micrometer, first obtain the thousandths reading, then see which of the lines on the Vernier coincide with a line on the thimble. If it is line marked "1" add one ten-thousandths, if it is line marked "2" add two ten-thousandths, if it is line marked "3" add three ten-thousandths, etc.

Example: Refer to figures A and B above.

The "2" line on sleeve is visible, representing .200"

There are two additional lines visible, each representing .025" 2 x .025" = .050"

Line "0" on the thimble coincides with the longitudinal line on the sleeve, representing .000"

The "0" lines on the Vernier coincide with lines on the thimble, representing .0000"

The Micrometer Reading is .2500"

Example: Refer to figure C above.

The "2" line on sleeve is visible, representing .200"

There are two additional lines visible, each representing .025" 2 x .025" = .050"

The longitudinal line on the sleeve lies between the "0" and "1" on the thimble indicating ten-thousanths of an inch are also to be added as read from the Vernier

The "7" line on the Vernier coincides with a line on the thimble, representing 7 x .0001" = .0007"

The Micrometer Reading is .2507"

TF16Z-0183

Figure 17. How to Read a Micrometer

HOW TO MEASURE A HOLE

Holes prepared with hand equipment have a tendency to be enlarged on the drill entrance side and get smaller toward the exit side. This is caused by vibration and wobble of cutting tool, excessive pressure on motor, or lack of rigidity and control of hand movement.

These are undesirable and unacceptable factors if they are allowed to exceed the drawing tolerance.

A good mechanic will know how to measure his work for acceptable quality. A Go-No-Go gauge will quickly detect incorrect holes; it will not measure the actual dimensions of the hole - other measuring devices must be used. A ball gauge and micrometer are used to obtain actual hole dimensions. Accuracy depends on the feel, skill, knowledge and experience of the user.

Steps for using a ball gauge.

1. Rotate ball gauge inside hole until it touches hole wall. Drag should be very light.

2. Rotate gauge again, if drag is not continuous, the hole is elongated. Readjust gauge to include elongation.

3. Move gauge to and fro in a longitudinal direction to detect belled or tapered hole.

4. Measure the ball with a micrometer. An accurate measurement depends on a delicate sense of feel.

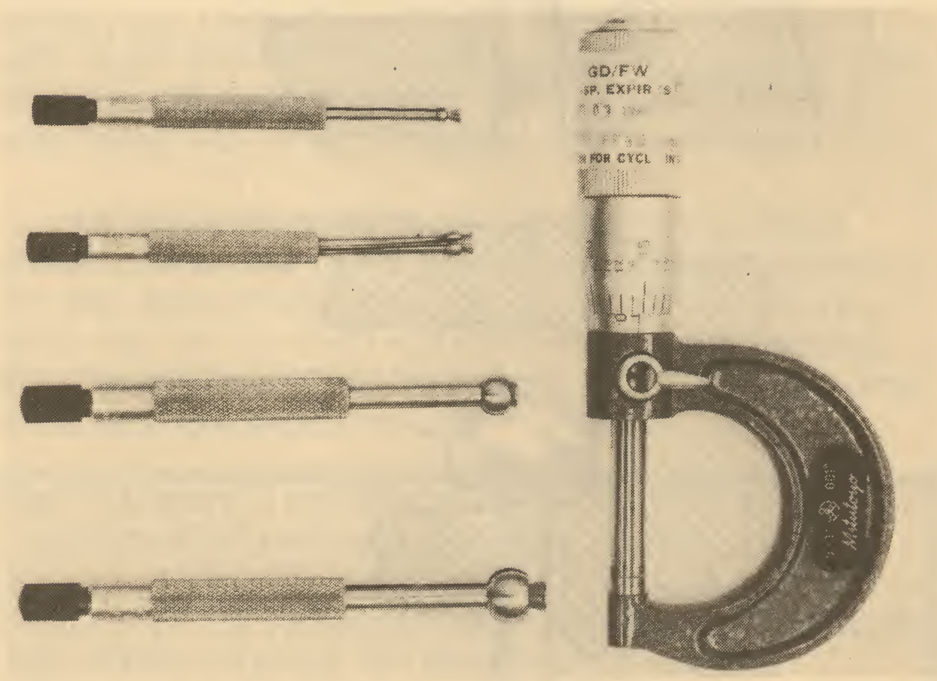


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Figure 18. Ball Gauges and Micrometer

SPOTFACING

A spotfacer is used to machine a smooth surface perpendicular to the axis of a hole in order to provide a flat surface on which the fastener head may be seated properly.

Inaccessible areas are machined by the use of a back-spotfacer.

Engineering drawings will specify when spotfacing is required for a particular operation.

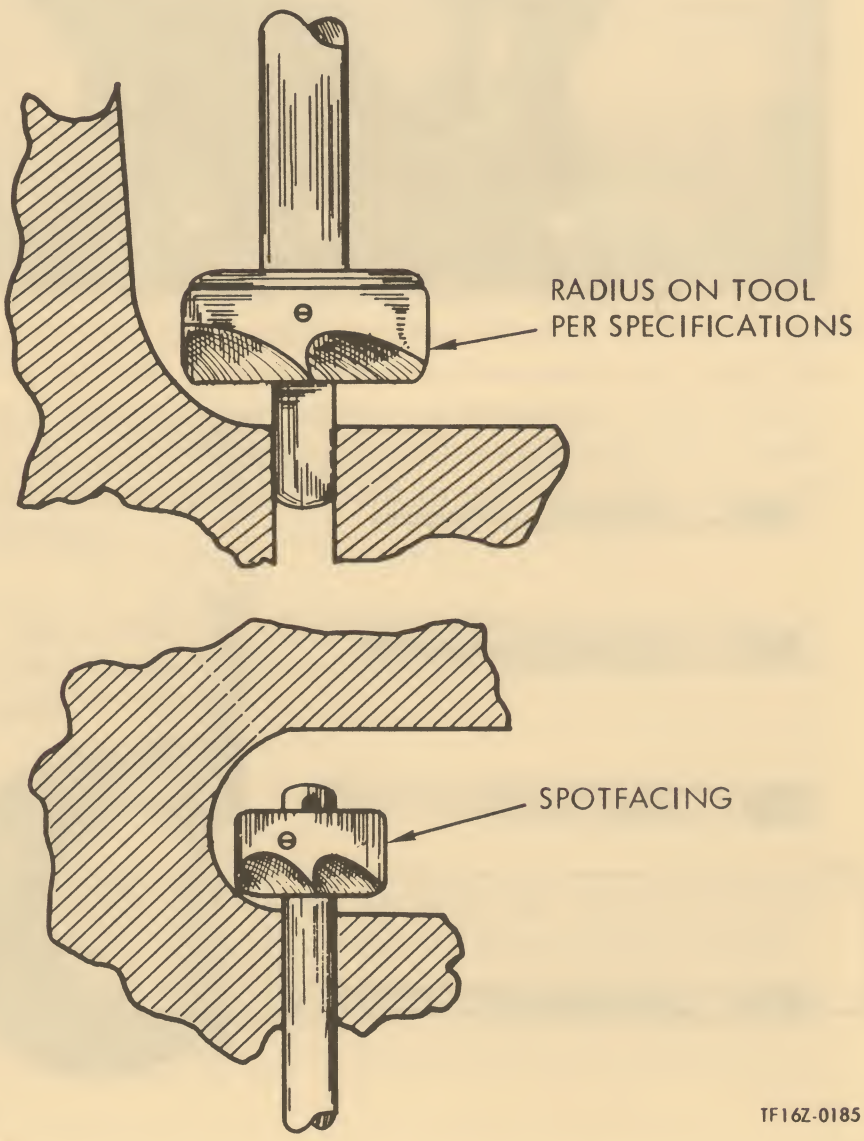

Figure 19. Spotfacing

A "Hole Finder" may be used to locate holes in outer skins over the pilot or predrilled hole in substructure. The pilot pin of a hole finder is inserted in the structure hole hidden beneath an upper layer of material. This will establish the drill bushing in line with the hidden hole.

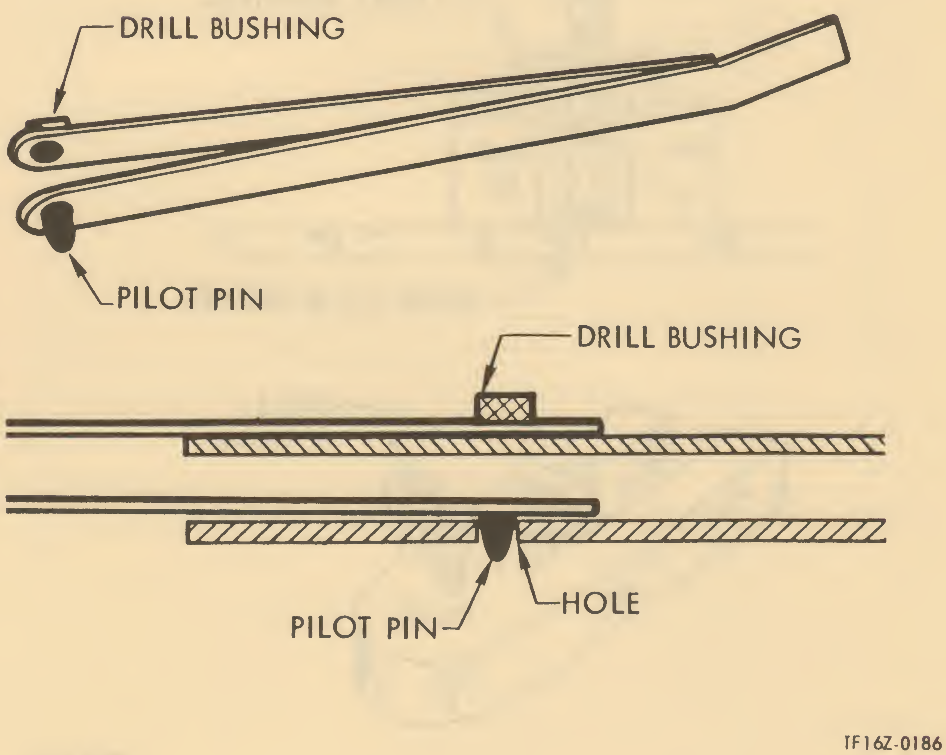

Figure 20. How To Use A Hole Finder

A "Pull Bar" is a device used to move a predrilled hole to the desired location. When a pilot hole is not accurately located a pull bar can be used to move it slightly in order to maintain edge distance.

The bar is fastened to the material with the drill bushing directly over the point of hole to be drilled. Because the bar cannot move and the drill is held rigidly by the bushing, the drill cannot slip into the off-centered pilot hole.

The bar has thus pulled the hole over to the desired position.

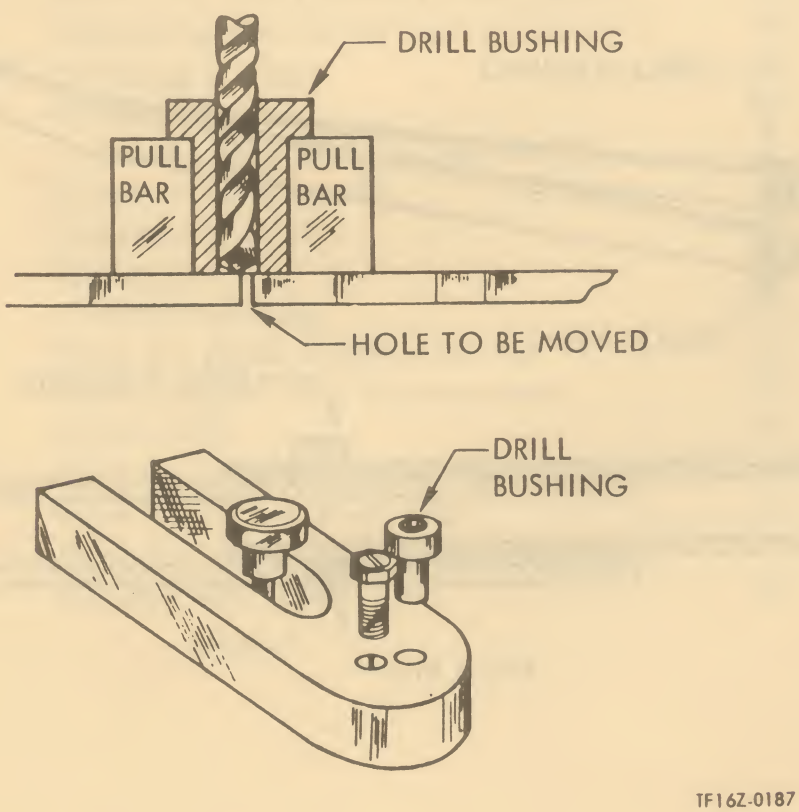

Figure 21. How To Use A Pull Bar

The proper use of drill bushings in tool fixtures, such as drill plates, drill blocks, and drill jigs, not only provides a more accurate assurance of drilling perpendicular holes, but it also reduces chatter and the tendency of a drill to "walk" across expensive material.

The tripod (or drill block) is used to help keep the drill 90 degrees to the material being drilled. On contoured surfaces it is shifted until the drill bushing is 90 degrees to the surface. This tool must be held firmly in place or it will shift and cause an inaccurate, misshapened hole to be drilled.

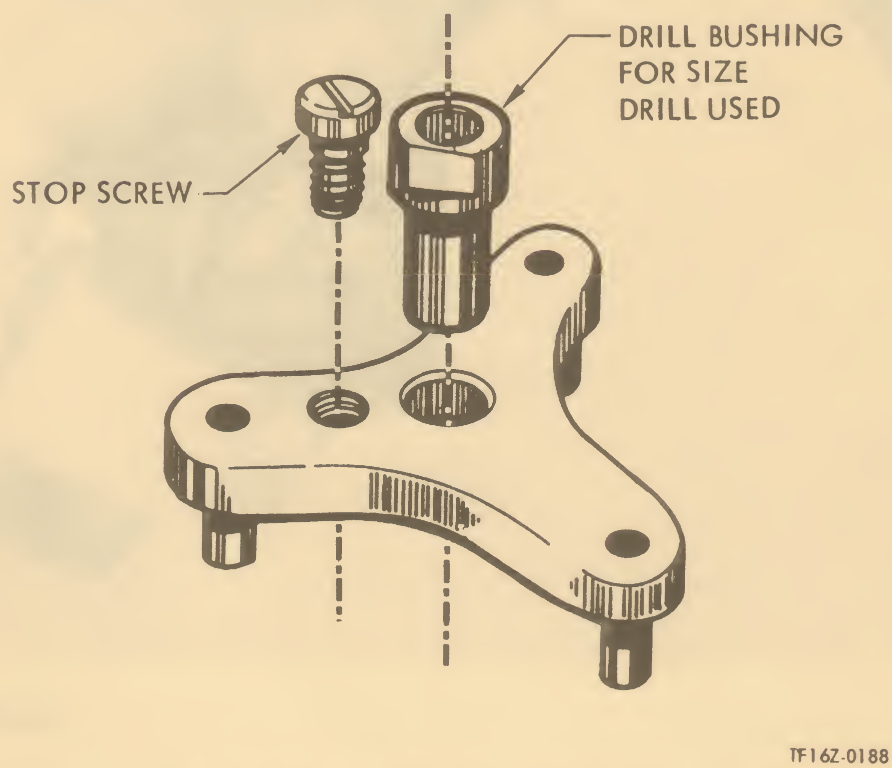

Figure 22. How To Use Drill Plates, Drill Blocks and Drill Jigs (Sheet 1)

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Figure 22. How To Use Drill Plates, Drill Blocks and Drill Jigs (Sheet 2)